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Environmental Determinism and Spurious Correlation: Just-so stories in phonology

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Abstract

The sounds and sound structures of languages often pattern in geographic clusters. Most accounts of this phenomenon rely on language contact and common descent as the principal causes of areal features. Modern linguistics rejects the notion that the nature of the location in which a language is spoken affects its phonological system. Nonetheless, some have argued that climate, topography, and other aspects of the ambient environment causally affect phonologies. The aim of this paper is to assess recent attempts in linguistics literature to broaden the view of what motivates geographically correlated phonological structures. I focus on the realms of phonology ostensibly affected by environmental factors; the purportedly adaptive phonetic pressures mediating these; and the mostly critical reactions of linguists to such studies. Ultimately, I conclude in agreement with most scholars that the evidence for environmental determinism in phonology is not compelling.

1. HISTORICAL BACKGROUND

Attempts to connect ambient factors and the sounds of languages are not new. Ideas of this sort permeated linguistic writings of the 18th and 19th century in particular. For instance, Herder writes in 1772 that "[c]limate [*Klima*], air and water, food and drink, will have an influence on the linguistic organs and naturally also on language" (2012, p. 148). Similar sentiments are espoused by Pinkerton (1794), de Rivarol (1784), Rousseau (1998 [1754]), and Grindon (1879). Beyond the effect of temperature, Grindon also writes that "habits, civilizations, barbarism, constitutional strength and weakness, all have their influence upon human articulation... Certain races of men seem, moreover, to possess peculiar and remarkable antipathies to particular sounds" (1879, p. 55). Obviously, Grindon fails to demonstrate causal links between any of these factors and phonology.

Phonological systems were furthermore viewed as climatically adaptive, as de Vere speculates in 1853: "[t]he same language may even change its nature when transported to distant regions, and many a colony bears witness to the effects of a colder or warmer climate, in its altered form and pronunciation from the mother tongue" (1853, p. 114). De Vere is convinced of the "degenerat[ive]" effect of migration on language, citing Asiatic Greek, Finnish dialects, and a language of the Sān people of southern Africa[1] (1853, pp. 114-15).

Despite the modern denunciation of the theory that climate exerts an influence on phonological systems, such ideas were accepted as fact in earlier centuries. As was typical of the time, these hypotheses were often proposed in tandem with

[1] De Vere refers to Finnish as Suomi, and to the Sān people as Bushmen. He does not name the language referenced; the ethnic group speaks a variety of languages of unrelated families.

unfounded, pseudoscientific ideas of racial predispositions, linguistic prescriptivism, and other supposed tendencies of languages which contemporary linguistics has completely dispensed with.

2. CONTEMPORARY REPRISE

Following the long period of problematic ideas of environmental determinism described above, there was a withdrawal from conceiving of language as dependent on or informed by its environment, due in part to the ascent of the Chomskyan view of language as innate and autonomous (Winter & Wedel, 2016). This rejection is felicitously summarized by Kaye, who writes:

> There is no correlation whatsoever between phonological structure… and the environment… [T]here is no reasonable scenario that would tie in phonological processes to such factors. Studying the structure of a language reveals absolutely nothing about either the people who speak it or the physical environment in which they live. (1989, p. 48)

Convention notwithstanding, among a small subset of linguists and anthropologists, interest in the environmental effects on language sounds has resurfaced in recent years. The work of these authors still centers heavily around the supposed effects of temperature and the nature of the air respired. Unlike their predecessors, contemporary authors interested in environmental correlates to phonology generally more clearly articulate: 1.) which domains are ostensibly affected, and 2.) which forces motivate the apparent correlations between environment and phonology.

2.1 The Munroe school: sonority and temperature

The resurgence in interest in theorizing causal links between environment and the sound patterns of language that I will highlight began in the 90s, with Munroe et al. (1996) hypothesizing that syllable structure is correlated with temperature. Specifically, the authors argue that languages spoken in warm regions rely more heavily on consonant-vowel (CV) syllables than those spoken in cold regions. They write that "people in warm to moderate climates, as inhabitants of 'outdoor' cultures... on average engage in more distal communication than people in cold climates... [S]uch distal communication... create[s] a need for optimal transmittal of messages, that is, high CV usage" (1996, p. 60). In order to demonstrate this effect, the authors select 53 languages from "geographically stratified" areas (so as to reduce the effect of areal diffusion and genetic relation), categorize each of these languages as being spoken in a 'warm/moderate' or 'cold' climate, compile word lists for each language, and calculate the frequency of CV syllables. They conclude that a positive correlation exists between ambient temperatures and frequency of CV syllables.

A similar approach is taken by Fought et al., who assign a sonority score to each of 14 classes of sounds, in accordance with the sonority hierarchy (2004). The authors assemble word lists for 60 languages, with every segment of a word receiving a sonority score. Average sonority scores are then calculated for each language, whereupon a trend arises in that languages spoken in warmer climates have overall higher sonority scores than their colder climate counterparts. Later work from Munroe et al. suggests that warm climate languages use both vowels and sonorant consonants more frequently (2009).

The contributions of Ember & Ember to the debate of sonority and temperature are unusual. These authors have written several articles in response to those of Fought et al. and Munroe et al., usually remarking on the correlations found and proposing multifaceted, decidedly unorthodox, alternative explanations for the phenomena. Ember & Ember propose that

frequency of CV sequences is directly related to the degree to which the infants of a society are held (1999); that foliage cover is an additional correlate of syllable structure (2000); and, outlandishly, that the languages of more sexually permissive societies have higher sonority scores (2007).

In Maddieson (2018b), the author seeks to ameliorate the issues of data binning and discrete categorization employed in prior studies by the Munroe school. The author uses distance from the equator as a rough proxy for temperature. Maddieson finds there to be "some correlation between lower sonority and distance from the Equator," remarking that this finding "aligns with the proposal in Fought et al. (2004) … that sound patterns in languages are in part designed in response to environmental factors" (2018b, p. 122). Similar sympathies are found in Maddieson & Coupé (2015) and Maddieson (2018a), in which the author corroborates the existence of a statistically significant correlation between sonority and temperature, though not between sonority and rugosity, elevation, precipitation, or tree cover.

2.2 The Everett school: ejectives and mountains; vowels/tones and humidity

Everett is another especially active proponent of contemporary environmental determinism, speculating that phonological systems are affected by both altitude and humidity. The earliest of the author's attempts to link phonology to environmental factors came with the publication of Everett (2013), which finds a correlation between higher altitudes and a propensity for ejective consonants. The argument is predicated on the fact that higher elevations reduce atmospheric and, consequently, pulmonic air pressure. Compressing a fixed volume of air by a constant factor—the approximate mechanism by which ejectives are produced within the oral cavity—is facilitated by the lower air pressure, according to Boyle's law. Everett (2013) also contends that in high elevation regions, which have lower rates of atmospheric water vapor, the reliance on ejective consonants as a means of retaining water vapor during speech might prove advantageous.

Everett (2013) relies on the *World Atlas of Linguistic Structures* database for information on the areas in which languages were historically spoken and whether those languages have ejective consonants. The author binarily categorizes each language along two metrics: 1.) whether where it is spoken lies within 200 kilometers of an area higher than 1,500 meters in altitude, and 2.) whether or not it has ejective consonants. Everett finds "a significant and positive worldwide correlation between elevation and the likelihood that a language employs ejective phonemes" (2013, p. 1).

In Everett et al. (2015), the authors take a similar approach to that of Everett (2013), relying on linguistics databases to find whether the use of "complex" tone is determined in part by humidity. Their hypothesis that such a correlation exists follows from the idea that the degree of precise control over the vocal folds needed for consistent production of pitch contrasts is more difficult to achieve in arid climates. The authors' findings affirm their hypothesis, and they conclude that "languages with complex tone require the pervasive implementation of… very precise phonation, which is… simply ill-suited to desiccated contexts" (Everett et al. 2015, p. 1326). The main findings of Everett et al. (2015) are reiterated one year later in Everett et al. (2016a).

Following a similar logic to that of Everett et al. (2015), Everett suggests in a later article that the relative rates of vowels and consonants across languages are additionally correlated with humidity (2017). While the proposed underlying bias against high rates of vowel usage in arid climates is nearly identical to that proposed to act against complex tonality in Everett et al. (2015), the methodology of Everett (2017) represents a starker departure from that of the earlier piece. Unlike Everett et al. (2015), Everett (2017) does not rely on the discrete categorization of languages (i.e. as having no, simple, or complex tone), but rather analyzes both language and climate

on continuous scales of vowel to consonant ratio and ambient humidity, respectively. Ultimately, Everett (2017) affirms the hypothesized correlation, noting the conspicuous exception of Australian languages, for which the trend is actually reversed.

3. CRITICAL RECEPTION

The work of the Munroe school appears to have been ignored by most scholars as not warranting formal response. It seems plausible that a number of factors could have bred such indifference, such as the dubious nature of the data binning strategies employed and the embrace of increasingly bizarre claims. Another source of such indifference was likely the failure to ground the basic assumptions stated in Munroe et al. (1996) that: 1.) societies in warmer climates are outdoors more often, 2.) outdoor communication entails higher degrees of distal communication, and, 3.) the degree to which distal communication is necessitated could be large enough to act as a pressure against the use of less sonorous phones.

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A notable exception to this rule of indifference is the informal and highly skeptical response of Collins (2019a; b). The author points out that the correlation originally found in Munroe et al. (1996) appears to be due to a flaw in methodology. Collins writes that "their statistically significant P value is an artefact of oversampling [zero] cold month languages… When I filtered all of the [zero] months of cold weather languages… there was no statistically significant correlation" (2019b). Collins criticizes other statistically unsound practices of the Munroe school, noting that analyzing climate using a discrete variable (i.e. number of cold months) rather than a continuous one constitutes a serious lapse in methodology (2019b). He is especially critical of Ember & Ember (2007), writing:

> Nothing about the paper follow[s] any sort of logic. Their research premise [i]s neither motivated by theory-internal predictions in linguistics, psychology, or anthropology, nor d[oes] the way they operationalise their variables make any sense, and the data they rel[y] on from other papers [i]s random and show[s] no correlation. (Collins, 2019a)

Though response to the contributions of the Munroe school is sparse, this is not the case with regard to the work of the Everett school. Everett (2013) garnered the attention of a number of linguists, and consensus has not prevailed as to whether the correlation between altitude and ejectives posited therein is significant. Hammarström (2013) finds neither the mean nor median altitude of languages with ejectives to be statistically significantly higher than the mean and median altitude of languages without ejectives. This author identifies an additional misjudgment of Everett (2013) in classifying languages according to *proximity* to high-altitude areas, rather than according to the *actual* altitude where a language is spoken; people can, as it turns out, live within 200 kilometers of a mountain and still reside at a low elevation. Despite this, Roberts affirms Everett's correlation, finding that "the presence of ejectives is in the top 1.4% of variables for predicting elevation" (2013). Roberts acknowledges, however, that Everett's correlation could be spurious, and that there are two linguistic features that are better predictors of elevation than the

presence of ejectives: 1.) order of object and verb, and 2.) relationship between the order of object and verb and the order of adjective and noun (Roberts, 2013). The cause of these correlations is, according to Roberts, unclear.

The reaction to Everett et al. (2015, 2016a)—which theorize a positive correlation between humidity and the use of complex tone—was greater than that to any other paper discussed here. Responses ranged from 1.) critiquing the authors' seemingly arbitrary distinction between "simple" and "complex" tone systems (Donohue, 2016; Hammarström, 2016; Ladd, 2016; Progovac & Ratliff, 2016), to 2.) noting the authors' conflation of pitch with tone (Donohue, 2016), to 3.) criticizing the supposed effect of ambient air desiccation on vocal fold dryness as reductive, hinting toward a more complex relation between humidity, temperature, and other factors (de Boer, 2016; Ladd, 2016), and to 4.) reiterating the need for corroborating diachronic evidence (Collins, 2016). Most of these responses also make note of the potentially confounding, well-established effects of language contact and relatedness. Many laud the merits of the adage "correlation does not imply causation." Some are more amenable to the authors' underlying hypothesis that "human languages are environmentally adaptive" (2015, p. 1326), whereas others still are much less accommodating. These two types of reactions are perhaps best exemplified by Winter & Wedel (2016) and Hammarström (2016). The former of these is duly cautious in outright championing Everett et al.'s findings but is nonetheless welcoming of the inquiries, heralding their work as an "exciting example of the transformation of the field of linguistics toward more evidence-based approaches" (Winter & Wedel, 2016, p. 82). The more skeptical sort of acknowledgement is epitomized by Hammarström, who critiques nearly every aspect of Everett et al. (2016), especially its apparently flawed statistical approach and lack of an unambiguous thesis on the alleged humidity-tonality interface, concluding that:

> [T]he theoretical motivation is too sweeping and... the empirical part referred to... problematic from start to finish. The statistical treatment of the empirical data on tonality and humidity fails to rule out the classical areal and genealogical confounds as well as statistical orthodoxy... [T]he ingenuity of the other strategies, along with a lack of concern for multiple testing, reflects poorly on the authors, reviewers, and editors who saw it through. (2016, pp. 68-69)

The tone of most counters to Everett et al. (2015, 2016a) lies between these two poles, and they universally point to the need for further evidence, a concern conceded to in Everett et al.'s own response to these rebuttals (2016b).[2]

4. SPURIOUS CORRELATION

The most widely shared response to recent literature arguing in favor of causal links between environmental factors and the sounds of languages has been to invoke spurious correlation as the explanatory force behind the disputed correlations. Spurious correlation is, as Roberts describes, "links between cultural features that come about by accidents of cultural history rather than being causally related" (2013). This reaction is best embodied by and articulated in Roberts & Winters (2013), which critiques the guiding methodology and validity of the findings of an array of papers interested in demonstrating causal effects of extralinguistic phenomena on language.

[2] For a useful evidence map of arguments against and in support of Everett et al. (2015), see Figure 1 in Roberts (2018).

These sorts of studies involving statistical analyses of cross-cultural traits are known as nomothetic studies (Roberts & Winters, 2013). They are especially prevalent currently, facilitated by the proliferation of large repositories of linguistic, cultural, and information broadly. Nomothetic studies present a number of challenges, chief among them, the difficulty of controlling for "cultures… related by descent… and by geographic diffusion" (Roberts & Winters, 2013, p. 1). The prospects of a study to properly control for such confounding variables are further diminished by other correlations that have also arisen out of nomothetic studies. This creates a series of complex interfaces between a number of language-external phenomena and language proper, summarized appositely by Roberts & Winters:

> Linguistic diversity is linked with climate…Climate affects the likelihood of cultural siestas… Cultures that take siestas tend to have languages with less morphological complexity… Morphological complexity is linked with group size… Group size is linked to the levels of extra-marital sex in a community… Levels of extra-marital sex have been linked to a language's phoneme inventory… Phoneme inventories have been linked to patterns of migration… Migration patterns are linked to the level of political collectivism in a culture… Collectivism is predicted by genetic factors… There are also genetic correlates of linguistic tone… Tonal languages co-occur with acacia trees… To bring the chain full-circle, the presence of *Acacia nilotica* also predicts a greater number of traffic accident fatalities, controlling for linguistic diversity, length of road network, GDP, distance from the equator, population size and population density… (2013, p. 7)

An additional problem identified by Roberts & Winters (2013) is that many nomothetic studies are backed by little to no prior reason to believe that the correlations they find ought to exist. Recall that there are two linguistic structures that correlate more strongly with altitude than does the presence of ejectives: 1.) order of object and verb, and 2.) relationship between the order of object and verb and the order of adjective and noun (Roberts, 2013). There is no apparent reason to believe this would be so; it is likely due to pure chance. Everett (2013) does not convincingly establish such grounding for his correlation, instead postulating that it could be due to a number of different, possibly competing factors. Without the existence of prior reason to suspect that ejectives and elevation should be directly related, this correlation should similarly be thought to be spurious.

5. THE PROBLEM OF PROOF

What constitutes the best evidence in support of the causality of environmental correlates to phonology would be multiple instances of geographically and genealogically distinct speech communities migrating from one climate to another and developing innovations thought to be associated with that climate over the course of successive generations (Collins, 2016). Historical case studies could play a pivotal role here, and Collins (2016) cites examples of migration to arid climates followed by subsequent loss of tone in a number of Sino-Tibetan and Niger-Congo languages. Unfortunately, controlling for historical relation and language contact in individual case studies is as difficult as it is in nomothetic studies. For the Sino-Tibetan languages examined, Collins finds proximity to Indo-European and Hmong-Mien languages to be much stronger predictors of few and many tonal contrasts, respectively. Moreover, Progovac & Ratliff (2016) cite Navajo and Apache as examples of languages that not only retained tonal contrasts 1,500 years after migrating from a humid to an arid climate, but in some cases developed even more tonal contrasts. A few

counterexamples do not entirely discredit the supposed causal nature of a correlation; Progovac & Ratliff instead liken the hypothesized effect of humidity on tone to that of smoking on lung cancer—even if the effect is causal, it is mediated by a multitude of other factors, and by no means predictive (2016).

Given the problems with historical case studies, the most promise lies in articulatory and perceptual experimentation investigating the validity of the hypothesized motivations of environmental correlates to phonology. Ladd suggests that Everett el al.'s correlation between humidity and tone could be supported by experimentation showing that "dry air… lead[s] to shallower spectral tilt than humid air," for example (2016, p. 72). Studies could certainly be designed to test the relative perceptual salience or ease of articulation of ejectives and their analogous pulmonic consonants at sea-level and high-altitudes. Such experiments could at least lend credence to the selective pressures of elevation and humidity posited by the Everett school.

6. CONCLUSION

The question of whether language-external factors have a causal effect on the shape that a language takes is by no means novel; it is precisely because of the extensive history of racist and unscientific attempts to answer this question in the affirmative that many contemporary researchers and linguists cringe at modern iterations of such inquiries (see also Greenhill, 2016). Recent attempts to posit correlations between the ambient environment and phonological systems do depart from those of past centuries, in that they view hypothesized links in less deterministic terms. Instead, proponents conceive of the synchronic geographic distribution of the sounds of languages as having arisen out of a confluence of well-established factors like linguistic genealogy and language contact, *as well as* the more eccentric environmentally correlated biases they believe exist. While deviation from orthodoxies of course shouldn't constitute grounds for immediate dismissal of a given hypothesis, there are also more pressing reasons to be skeptical of alleged environmental influences on phonology.

Though not even unanimously accepted as methodologically and statistically sound, the studies discussed here are plagued by additional unresolved (perhaps unresolvable) issues. The correlations they find are often spurious, and it is staggeringly difficult to filter out the confounding effects of variables like familial relation and language contact. The likelihood that a study can properly control for these and other hypothesized extralinguistic determinants of phonology—including genetics (Creanza et al., 2015; DeMille et al., 2018), anatomy (Moisik & Dediu, 2017), population size (Hay & Bauer, 2007), and a host of others[3]—is approximately null. Out of this multiplicity of possible mediating factors emerges the crucial question of the scope of the effects. Compounding these problems is a lack of supporting evidence, both historical and experimental. Ultimately, the environmental properties proposed to affect phonology have not been sufficiently demonstrated to be credible.

As I draw to a close, I am reminded of the epigram popularized by Mark Twain: "there are three kinds of lies: lies, damned lies, and statistics." The studies I've examined here should serve as a cautionary tale against irresponsible statistical methodologies for researchers of all stripes. A particularly salient question in linguistics currently is how to hold academics accountable for statistical malpractice, especially when there could be harmful, racialized implications.[4] To be clear, none of the papers I've examined here appear to be racist in vacuo (from what I can tell). It is imperative that these studies be understood

[3] See Dediu et al. (2017), Roberts & Winters (2013) for more comprehensive lists.

[4] See the recent open letter to the LSA regarding Steven Pinker's misconstruction of statistics on police shootings and race.

in their proper historical context. Insofar as questions of this sort are to be further interrogated, future authors interested in environmental determinism in linguistics must be careful to sedulously distinguish the motivations and implications of their research from the racialized paradigms of the work promulgated in prior eras of similar traditions

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